Serious Moral Games in Bioethics

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Workshop on “Ubiquitous games and gamification for promoting behavior change and wellbeing”

Held in the 10th edition of CHI Italy, the biannual Conference of the Italian SIGCHI Chapter

September 16, 2013

Trento, Italy

Foreword

The workshop on **“Ubiquitous games and gamification for promoting behavior change and wellbeing”** is the first workshop at CHI Italy promoting the gathering of researchers, professors, students, and practitioners in the field of game industry, healthcare, HCI, and UbiComp related domains to discuss how ubiquitous games can influence the attitudes, health and behaviors of people, and how can they be used to change human behavior to promote wellbeing. This workshop covers topics such as gamification, ubiquitous games interaction experiences, serious games, games and virtual environments for rehabilitation and recognition of behaviors.

On behalf of the entire organizing committee and all of the individuals involved in making this workshop happen, it is our great pleasure to welcome you to the vibrant city of Trento where the workshop is going to be held. Trento can be proud of being one of the most eclectic cities in the world in terms of people, food, architecture, history, and entertainment. We are sure that you will have a great time in this great city. We encourage you to explore it and its adventurous surroundings.

This year, we have an engaging technical program due partly to the high-quality submissions we received and a world- class program committee. Our international Program Committee is composed of 20 leading researchers in the field of videogames, HCI and pervasive healthcare who evaluated 11 submissions. Using a multi-phase review process each submission was reviewed by at least three members of the program committee. In total, the Program Committee spent countless hours providing feedback to the authors through close to 30 reviews, and after an online discussion 9 submissions were accepted for publication in these proceedings. The review process has resulted in a high-quality set of published papers. We give many thanks to those who invested considerable time in reviewing, selecting, and suggesting the best works to be presented in this workshop.

The technical program of this year includes traditional and novel topics around user experience, usability, emotion recognition, behavioral changes, physical interaction and a variety of other works such as visualization of information.

Apart from the technical sessions involving the presentation of talks of the accepted papers we have a discussion and it is fair to say that we are very excited to have **David Tacconi,** startupper, Founder and CEO at CoRehab.

All in all, the program seems promising and sensational. We highly encourage you to get together with others within our compact community. Get to know others through the informal meetings in the hallway, the hall room, at a local bar, or simply by having lunch together. After all, this is what truly helps strengthen the ties within a community.

Monica Tentori, Nadia Berthouze, Stefano De Paoli, Michela Ferron, Yongqiang Lyu, Sergio F. Ochoa, and Paolo Massa, Ubigames for health 2013 Technical Program Co-chairs

Workshop Organizers

Monica Tentori is an Assistant Professor in the computer science department at CICESE. Since 2009, and taking into account her experience in designing and pilot-testing ubicomp in support of hospital work, she has been studying how ubiquitous environments may effectively enhance the interactions of children with autism with their world. She recently served as the PC Co-Chair for PervasiveHealth 2012 and MexIHC 2012. She was awarded with the prestigious “Microsfot Faculty Fellowship” award in 2013. She holds a B.S. from UABC and received a M.Sc. and Ph.D. from CICESE. She did her postdoctoral training at UC Irvine.

Nadia Berthouze is a Reader at the UCL Interaction Centre, University College London, UK. Her current research focuses on studying body movement as a medium to automatically recognize, support and regulate people’s affective experiences. In 2006, she was awarded an EU FP6 International Marie Curie Reintegration Grant to investigate the above issues in the clinical and entertainment contexts. She is leading a EPSRC collaborative project on affective-aware rehabilitation technology to motivate people with chronic pain to do physical activity.

Yongqiang Lyu is an Assistant Professor at HCI lab, Tsinghua University, China. He received his Master and Ph.D. degrees from Tsinghua University in 2003 and 2006 respectively, and he has been working in Tsinghua University since 2009 after three-year work in industry. His current research focuses on studying the measurement and evaluation tools and methodologies for the user experience in HCI with a quantitative manner. Current achievements on the methodology and measuring sensors have shown it promising. He is also leading a group working with clinical professionals in China to serve the citizens in both rural areas and cities to improve their health management. He served as demo chair in UbiComp 2011 and local chair in Healthcom 2012.

Sergio F. Ochoa is an Associate Professor of Computer Science at the University of Chile. He received his Ph.D. in Computer Science from the Catholic University of Chile. His research interests include mobile and ubiquitous computing, computer-supported collaborative work, and software engineering. Dr. Ochoa is a member of IEEE, ACM and the Chilean Computer Society and sits on the Steering Committee of the LACCIR (Latin American and Caribbean Collaborative ITC Research Initiative). He is also member of the IEEE SMC Technical Committee.

Stefano De Paoli is researcher at <ahref Foundation in Trento (Italy). After obtaining a PhD in Sociology and Social Research at the University of Trento in 2008, Stefano De Paoli worked for about three years at the National

University of Ireland at Maynooth, focusing on Reputation, Massively Multiplayer Online Games and interdisciplinary research in Social and Computer Sciences. Leading researcher at <ahref since December 2010, he covers issues at the intersection of technology and society -- along with studies on gamification, new media for local communities, and massive multiplayer online games. Stefano has also taught university classes on technology and society, intellectual property in ICT, and information system management.

Michela Ferron is a researcher at the Intelligent Interfaces & Interaction research unit of the Fondazione Bruno Kessler in Trento, Italy. Her current research examines the cognitive and social aspects of persuasive mobile interfaces, applying gamification techniques and psychological motivational strategies to encourage physical activity. Michela completed her PhD at the Center for Mind/Brain Sciences of the University of Trento. Her main research interests include psychological aspects of social networking and user-centered interaction design.

Paolo Massa is a researcher at the Intelligent Interfaces & Interaction research unit of the Fondazione Bruno Kessler in Trento, Italy. He received his PhD from ICT International Graduate School of University of Trento in March 2006, defending a thesis titled “Trust-aware Decentralized Recommender Systems”. Paolo’s research interests include trust and reputation, recommender systems, gamification and social networking and commons-based peer production phenomena such as Wikipedia.

Program Committee

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Additional reviewers

- Yongqiang Qin, Tsinghua University
- Loanna Lacovides, University College London Interaction Centre (UCLIC)

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Tiago Gomes, Tiago Abade, Michael Harrison,
José Luís Silva and José Creissac-Campos

Keynote speaker

David Tacconi

David Tacconi has 10 years of experience as researcher, software developer and CTO in wireless industry, e-healthcare and pervasive computing. David Tacconi is a 34 year old entrepreneur, father of 2 children and with a degree and a Ph.D in Telecommunication Engineering from the University of Florence. David has been working with Telecom Italia as software developer for 1 year, with Create-Net research center as researcher in pervasive computing for 4 years and with Futur3, an italian start-up, as CTO for 4 years. Since July 2012 he is the founder and CEO of CoRehab (www.corehab.com, youtube.com/corehab, @corehab_italy, a company that is building a brand new product for a better rehabilitation and PT with enhanced motivation of the patient and remote control by physiotherapists.

Title: *"Riablo™ by CoRehab: therapeutic games for orthopaedic rehabilitation"*

Abstract:
Riablo is a brand new product that allows patients to carry out all the exercises assigned independently, with the feeling they are being looked after (and indeed they are) at all times, but with a minimum amount of time required on the part of the professional. Riablo allows the patient to perform the usual exercises with the "therapeutic games" designed by CoRehab using inertial and pressure sensors for motion measurements.

The road to the final version of Riablo started one year ago using the lean startup method, building and testing minimum viable products every 2 months with real patients in hospitals and rehabilitation centers. A great focus was put on therapeutic games, the audio and video feedbacks provided to the patients and finally the gamification and motivational aspects, everything through quantitative and qualitative analysis. Even though the design started following requirements typical of the videogames world, we were forced to follow the special needs of patients, since they use Riablo to perform their usual exercise and focus mostly about the exercise related information rather than about gaming aspects.

In this presentation, we will show the steps guided by real experience and real tests toward the final design of Riablo and the final version (with a live demo) ready to be launched on the international market.

iFlit: an ambient display to induce cognitive dissonance and behavior change

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Abstract
In this paper, we present preliminary work on how persuasive ambient displays could induce cognitive dissonance to promote positive behavior change among graduate students. The paper presents the concept and the design of iFlit –an interactive and collective ambient display that enables a group of students to reflect on their burnout level, and sleeping and activity habits. iFlit metaphor shows a garden with birds representing students' monitored behavior. Birds move according to users' activity level, and the garden's background changes according to each user's sleeping habits. Users match peers perceived burnout, and sleep and activity habits to induce cognitive dissonance. We argue such displays are more efficient than personal devices to empower individuals' self-reflection due their capabilities for enabling a playful interaction with their personal data.

Author Keywords
Ambient display; dissonance cognitive; perception change; behavior change;

Introduction
Cognitive dissonance is a psychological state that appears in a person experiencing simultaneously two or

more conflicting cognitions such as thoughts, emotions, or intended behaviors. When individuals are motivated to reduce or eliminate dissonance, they tend to change their behavior or beliefs [1]. In other cases people can reduce the presence of dissonance by avoiding specific conflicting information or situations that may produce or reinforce the dissonance. In contrast, the increase of cognitive dissonance may trigger the questioning of owns beliefs and therefore can be used as a way to intervene towards rising personal self-awareness.

Recent research projects are focusing on increasing the awareness of people mental and physical state by enabling individuals to collect and share personal data related to their behavior, habits, and thoughts. As an example, persuasive ambient displays are used to provide individuals with continuous awareness of this myriad of personal data increasing self-reflection and increasing the opportunities for individuals to experience cognitive dissonance [10]. Furthermore, strategies derived from cognitive science theories are mostly used when designing such persuasive ambient displays, in particular theories based on the social influence on people’s behaviour as the Presentation of Self-[9] and Cognitive Dissonance Theory [3]. The first describes how individuals attempt to manage the impressions they want others to have of them, while the second describes how individuals manage the discomfort experienced when two or more conflicts cognitions are present.

In this paper, we explore how cognitive dissonance could be used to persuade positive behaviour changes in individuals’ lifestyles through the design of a persuasive ambient display. We studied the impact of cognitive dissonance among graduate students as they experience poor lifestyle habits resulting from their sense of responsibility, and inability to complete academic tasks and excessive workload.

A moderate level of physical activities can improve cardiovascular functions, reduce the risk of diabetes and obesity; and also impacts sleep quality and mental wellbeing. Recent studies have shown that sleep plays an important role in learning processes and memory consolidation [13] and is fundamental in school achievement and academic performance [7,8]. Daytime habits, sleep routine, and lifestyle have resulted in sleep disorders and insomnia cases [12]; however many emotional issues, such as stress, anxiety, and depression are the main causes. Psychological and physical fatigue also have a strong impact on sleep efficiency.

Taking into account this evidence, we designed a persuasive ambient display (iFlit) that monitors student’s physical activity, sleep quality, and burnout as predictors for determining when a user is following a healthy lifestyle and how others perceived users wellbeing. iFlit design is based on serious game approach enabling direct interaction of users with the display, comparison and collaboration among users, and rewards represented by environment animations targeting increase of user engagement. The rest of this paper includes a description of related work, then the development of the system, and conclude with future research plans.

Related work

The Ubicomp and HCI communities have explored the design and evaluation of innovative technologies to motivate people to change their perception and/or behavior. An example of technologies using cognitive dissonance for behavior change was proposed by Dickerson et al. In their experiments they show that people were motivated to save water when reflecting on their own data regarding shower usage . Awareness about discrepancy among what their behavior perception and their real behavior have aroused mild feelings of hypocrisies and motivated them to change their attitudes to eliminate this situation. Other studies show how cognitive dissonance it’s not only induced by the comparison with his-self or self-esteem but demonstrate social behavior also strongly influence behavior change. Carkenord and Bullington [4] shown how it’s possible to induce cognitive dissonance among students comparing their attitudes and behaviors on a variety of social issues.

Figure 2. Ambient application showing the birds representing users and their activity level –data gathered from the smartphone

One of the strategies most often used in persuading behavior change is to share personal information on social networks, and compare data monitored by devices with the same data of friends. BinCam [2], a social persuasive system aiming to motivate reflection and behavioral change in food waste and recycling habits of young adults, using a smartphone installed on the underside of the bin that take pictures to the food waste and upoload them to Facebook. Results of this study shown how social influence can be considered as a source of change and can help increase people’ attitudes and awareness.

Breakway[3] is an aesthetic and lifelike ambient display encouraging people whose job requires them to sit for long periods of time to take breaks more frequently. It consists in a small sculpture placed on the desk whose shape and movement reflect the form of the human body; an upright position reflecting the body’s refreshed pose, and a slouching position reflecting the body’s pose after sitting for a long time. Similar projects are used to inform users about their impact of their everyday activity on their living ecosystem, as Coralog [5] and Wattsup [6]. Our work is motivated also by extensive research about benefits derived by the increase of a moderate level of physical activity[14]. Physical activity can help people improve their quality of sleep and therefore to improve cognitive state and eventually academic performance[7].

In iFlit we want to explore the use of social and collective feedback on a public ambient display to induce cognitive dissonance as a trigger for increasing self awareness of people in an aggregated way.

Developing iFlit

We followed a user-centered design methodology to design and develop iFlit –an interactive and collective ambient display that enables a group of users to reflect on their burnout level, sleeping and physical activity habits. IFlit interface shows a metaphor consisting on a garden with birds representing users (Figure 1).

Virtual characters representing birds were designed to provide continuous peripheral awareness while being friendly/affable. Birds move according to users’ activity level, and the garden’s background changes according to each user’s sleeping habits. Attachment to the virtual pet allows a user to be engaged in the game and to avoid negative reinforcements reflected on the pet, as a consequence a user might be more motivated to the change behaviour [13]. A user reports burnout level answering surveys based on the Workload TLX and the

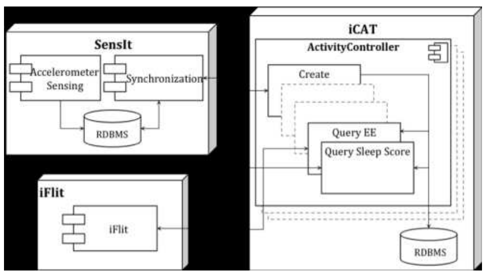

Figure 2. Architecture of iFit

Figure 3. User data displayed when a user gestures are recognized

Maslach Burnout Inventory Survey on a mobile phone. The smartphone’s accelerometer running SensIT is used to automatically detect individuals sleeping quality and overall activity level.

SensIt is an Android application that runs in the background and is constantly sensing the user’s physical activity (activity counts, Figure 2). Sensed data is stored locally and then synchronized whenever a Wi-Fi connection becomes available. iCAT is a RESTful web service used by SensIt and iFlit to upload sensed data and query users’ activity-related information respectively. iCAT computes energy expenditure and sleep quality from users’ activity counts.

The Smartphone’s app uploads the user’s information to the cloud which is periodically queried by iFlit and presented later in the form of charts (Figure 3). If the users want to know about the information gathered, the system also provides a natural user interface for consulting it implementing a gesture based navigation. We use the Microsoft Kinect sensor to capture the user presence and the navigation commands. For example if the user steps in front of the system, the interface acknowledges this and provides some feedback like wind movement. The users can select a particular character representing a user’s information using the hand tracking position and later move through the charts waving the hand once inside the window interface. Figure 2 shows the user interface of iFlit in which each character represents a specific user.

We deployed the display in a meeting room where students often gather to study either alone or independently.

Conclusions and Future Works

We presented the design and development of iFlit. Awareness about student’ stress and fatigue was also induce through a visual report on iFlit. We are currently gathering data from accelerometer about physical activity and sleep efficiency, and we are analyzing data about burnout. For a period of six weeks we will intend to observe the interaction of the students with iFlit and analyze student’s behavior. Results from this pilot study will help us improve strategies to induce dissonance and verify our hypothesis related to the efficiency of a collective social feedback on public monitor to motivate a small community to adopt a healthy lifestyle.

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Froggy Bobby: An Exergame for Children with Motor Skills Problems

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Abstract
Physical therapy helps children with Developmental Coordination Disorder (DCD) to generalize motor functions executing different physical exercises through practice, repetition, and guidance. Children find task-repetition boring and guidance could not be provided outside the therapy-room in real life situations. Exergames are good in supporting motor therapeutic interventions as children find them engaging, but little has been said about if the practicing of motor skills through exergaming enables skills generalization. In this work, we present the results of a qualitative study that led to the design of *Froggy Bobby* –an exergame supporting the motor skills generalization of children with DCD. The results of a formative evaluation of *Froggy Bobby* with 24 typical children show *Froggy Bobby* is perceived useful and easy to use. We conclude with directions for future work.

Introduction
Developmental Coordination Disorder (DCD) is a marked or serious impairment in the development of motor function and coordination [1] leading to sensory impairments, and problems in gross and fine motor skills [2]. Physical therapy or motor training, which demands individuals to practice different physical exercises through repetition and step-by-step guidance from trained specialists, enables over time motor skills

(a) **(b)**

Figure 1. Design process: (a) the design team during one participatory design session; (b) mock-ups of the proposed low-fidelity prototypes.

retention and generalization [9]. Skills generalization occurs when a user transfers training across various settings, people, and stimuli, using the newly learned skill without help and under conditions different from the ones used during training [3]. Conducting a successful physical therapy is challenging, as children find task-repetition boring, and the motor exercises used during the training lack of the realism to help children generalize from the therapy-room to other environments when specialists are not at their side [2].

It has been demonstrated that exergames can be a good tool for use with therapeutic purposes for motor functioning [7] and help children to practice motor skills at “anytime and anywhere” [11]. In this paper, we describe an exergame designed to improve motor coordination and promote motor skills generalization to support children with DCD.

Related work

In the literature, several projects have investigated how exergames could be used for entertainment (e.g., *Dance Dance Revolution* [4]), promoting physical activity (*Astrojumper* [6]), and motor rehabilitation (e.g. *Arrow Attack* [5]) in support of different populations (e.g., children with cerebral palsy [8], older adults [10], and stroke patients [5]). For example, [8] presents an exergame that enables children with cerebral palsy to use a rehabilitation bicycle to control an avatar who has to ride a unicycle while carrying a tray full of eggs in each hand. This study shows that using exergames benefits physical activity, which may have an impact on health [11] and in motor skills rehabilitation [5]. However, none of these studies show the usefulness and feasibility on using exergaming for motor skills generalization.

Methods

For a period of 4 months, we conducted a qualitative study at a public rehabilitation center located in Ensenada, Mexico where 10 trained specialists (i.e., psychologists, physical therapist, rehabilitation doctor, occupational therapist) serve approximately 100 patients with different motor impairments. We interviewed 5 specialists and observed how they conduct the motor therapies at this clinic. Interviews lasted around one hour and the time of observation was about a half of hour per therapy session. A total of eight therapies were observed. We used affinity diagramming to group quotes obtained from interviews and observation-notes, and uncover potential emerging themes related to our problem.

Designing Froggy Bobby

The results of the qualitative study indicate that motor therapies involve short-term goals to help children practice motor skills through the repetition of motor exercises, and that each exercise matches a potential motor skill that children could later use in real life situations for self-caring (e.g., crossing arms when dressing) or practicing sports (e.g., kicking the ball to play football).

We used the results of the study to iteratively design several low-fidelity prototypes (Figure 1) that exploit the short-term skills generalization goals, and motor exercises children with DCD practice during physical therapies. The low-fidelity prototypes were discussed during several participatory design sessions that help us to select the more appropriate prototype to develop.

We envisioned *Froggy Bobby*, an interactive exergame to help children improve motor coordination and

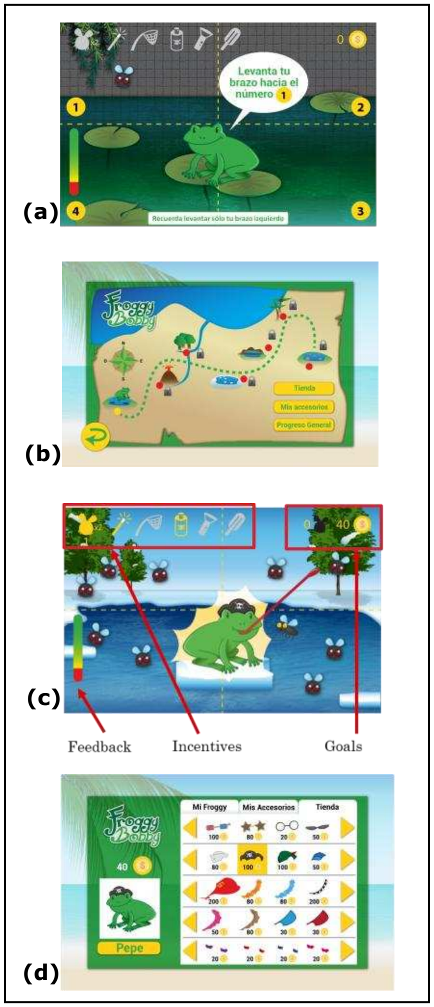

Figure 2. *Froggy Bobby*´s Screenshots: (a) Bobby asks a child to move their arms up, down, right, and left to take the baseline; (b) Map to show the levels of the game; (c) Bobby catching flies and taking powerful flies; (d) Store where children can buy different accessories to personalize *Bobby*.

generalize motor skills (Figure 2). When using *Froggy Bobby*, children move their arms in a coordinated manner to catch multiple-colored flies by controlling the tongue of the avatar: the frog *Bobby*. Children must catch as many flies as they can to help Bobby feed friends and relatives. *Froggy Bobby* has 6 difficult levels varying the amount of prompting children gain from the game, the difficulty for catching flies, and the coordination exercises children use to catch flies. These coordination exercises mimic typical motor exercises children practice during therapies and were identified appropriated by therapists in our design team. During levels 1-3, *Froggy Bobby* draws flies’ trajectories demanding children to move their arms from side to side catching multiple-colored flies; on levels 4-5, *Froggy Bobby* demands children to move arms down, up, right, left to avoid “mad” mosquitoes that make the frog feel sick; and on level 6, *Froggy Bobby* asks children to match movements with a color to catch only the flies matching such color.

On each level and for every fly caught, children earn points and coins they could later exchange for items to personalize their avatar (e.g., hats, eyeglasses, shoes) or powerful flies they could use to their benefit (e.g., disappear all the “mad” mosquitoes, Figure 2d). *Froggy Bobby* proportionally controls flies’ speed according to children’s activity intensity. Each level has a goal a child has to complete to move onto the next level (i.e., catch a pre-determined number of flies) –e.g., in level 1, children have to catch 20 flies. The number of flies increases on each level.

After each level, children have to play a mini-game that demands from the child to use the previously practiced coordination movements to achieve a specific motor skill useful for self-caring and practicing sports (e.g., dressing/undressing, throw a ball in a specific point).

To show how children use *Froggy Bobby* here we present a scenario:

Max, an 8-year old child with DCD, uses *Froggy Bobby* to practice coordination movements and motor skills. *Froggy Bobby* asks Max to move his arms up, down, right, and left to discover the distance between Max’s arms and each quadrant on the screen (Figure 2a). *Froggy Bobby* uses this information to decide the maximum and minimum level where flies and mosquitoes could be placed on the screen. Max navigates between levels displayed on a map (Figure 2b) and enters level 1 where multiple-colored flies fly around the frog Bobby. Max moves his arms from side to side moving *Bobby’s* tongue to catch flies (Figure 2c). Max moves rapidly earning 20 coins and points, as he catches 20 flies (i.e., the number of flies required for completing this level). Then, *Froggy Bobby* asks Max to move his arms coordinately mimicking taking off his shirt. Max executes the movements correctly and earns 50 more coins. Finally, Max uses his coins to buy Bobby a hat (Figure 2d).

Preliminary formative evaluation

We gathered feedback from 24 typical children to uncover new design insights to improve *Froggy Bobby*’s design, and get a sense of potential users’ engagement, and usefulness, ease of use and perceived intention to use *Froggy Bobby*. We presented a video showing different scenarios of children using *Froggy Bobby,* and asked participants to answer a survey including topics related to perceived acceptance, engagement, and potential new design features.

Results show that 96% of participants would use *Froggy Bobby*, and believe it would enhance motor coordination. 83% perceived *Froggy Bobby* is easy to use, and all children expressed *Froggy Bobby* and the motor-exercises are fun. 96% perceived the avatar is interesting and fun, and provided us with additional insights for improving our design —*e.g.,* include other avatars like monkeys or bears for catching bananas or bees, and to use legs to step on bugs.

Conclusion and future work

Although the results from our formative evaluation are promising, we still require to evaluate *Froggy Bobby*'s design, the physical exercises we chose to control the avatar, and the motor skills support, with specialists. We plan to conduct several focus groups with specialists in motor rehabilitation and psychologists to further validate and improve our design. Then, after development, we will deploy it in the home of several children with DCD to investigate the exergame's impact in motor skills generalization. We expect that the results from the deployment phase will help us to redesign the system in order to incorporate new features that could extend our understanding of the design space of exergames for achieving motor skills generalization in real life situations.

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Designing Meaningful Game Experiences for Rehabilitation and Sustainable Mobility Settings

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Abstract
This paper presents the approach followed in two ongoing research projects aimed to designing meaningful game-based experiences to support home rehabilitation, eco-sustainable mobility goals and more in general better daily lifestyles. We first introduce the need for designing meaningful game-based experiences that are well-connected to the relevant non-game settings and can be customized by/for users, then, we show examples of how this approach can be realized in the rehabilitation and sustainable mobility contexts.

Author Keywords
Home Rehabilitation, Sustainable Mobility, Persuasive Technology, Gamification

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design; Experimentation

Introduction
This paper reports recent work conducted in the context of the REHAB@HOME and SUPERHUB European

projects [4, 5], where we are deploying user-centred design methods to understand how to realize meaningful game-based experiences for rehabilitation and sustainable mobility purposes. As reported also in [3, 6] the concept of putting the user at the center of a gamification or game design process is key to realize meaningful, effective experiences for users and achieve behavior change goals [2]. Meaningful game design is more challenging to create, since designers cannot rely on well-known strategies or rules (e.g., just assign points to a player leading to external rewards), but need to make game elements come out of aspects of the underlying activity that are meaningful to the user. Previous work has shown that providing only external rewards to motivate change might not be enough to produce the desired outcomes, nor be an ideal solution [1,2,3,6]; instead, providing clear connections between the game elements and important aspects of the relevant non-game activity (as well as user’s own goals and desires) can bring more benefits and stable outcomes. Also, since users have different needs and preferences, another design challenge consists in providing a flexible gaming environment that can be personalized and customized to meet individual needs and be perceived as meaningful by the different target users. In the following sections, we discuss how these design principles and challenges are being addressed in the two design scenarios of REHAB@HOME and SUPERHUB.

Game-based Rehabilitation Scenarios

The REHAB@HOME project [4] aims to develop an innovative, effective game-based rehabilitation solution for physically and/or cognitively challenged people (e.g., post-stroke, Multiple Sclerosis, Parkinson patients) in order to increase their compliance and motivation to follow rehabilitation programs at home. The project aims at integrating state-of-the art, low-cost gaming platforms (such as Wii, Kinect and the upcoming LeapMotion) together with sensor based collection of relevant patient data and personalization, to provide an enriched, contextualized serious-game based environment where patients can exercise individually or connected with other patients through social networks. Therefore, the project aims at transforming the patient's home into a place, where physical and cognitive rehabilitation processes can be performed in an intensive, engaging and professionally guided way, while promoting social inclusion and quality of life. During the first 6 months of the project, scenario-based interviews with 10 patients visiting Fondazione Don Gnocchi rehabilitation centre (Milan, Italy) were carried out to better understand patients’ requirements and expectations regarding the technological solution to be designed. From the data collected two main indications for the design of the game-based solution were derived from patients: a) the platform should be easy-to-use and set up, propose exercises and movements (to achieve the game objectives) that are closely related to Activities of Daily Living (ADL), meaningful from a user perspective; b) the game solution should be personalized to the specific needs, impairments, preferences of a user and provide a clear feedback regarding the correct execution of movements and patient’s progress over time.
Based on these users’ suggestions we are now in the process of developing a first prototype solution of the gaming environment for a pilot experimentation, by focusing on supporting rehabilitation of the upper body through exercises that can be easily matched with ADL, like reaching out for home objects and moving them to specific places, making fine-grained movements with

Fig.1: Eco-Dealers mission example

one’s fingers like it is required by playing a musical instrument. The game-based solution will also be modular (different games will be made available over time), highly flexible and personalized according to patient needs (e.g., range and intensity of movements required to play will be made easy to calibrate by the patient or therapist before and during the rehabilitation program). Game scores and audio-visual feedback will be designed to allow an effective monitoring of correct execution of the target movements and to provide information on progress achieved in order to sustain patient motivation over time.

Game Experiences for Sustainable Mobility

In the SUPERHUB project [5] we are developing a citizen-centred open platform to support multi-modal urban mobility, by deploying also persuasive technology and personalized journey planning services to facilitate the adoption of more eco-friendly travel choices by users.

Among the different persuasive strategies and services designed to fit the several user profiles and support behavior change, we have developed also a serious game, named *Eco-Dealers*. Focus groups conducted in Milan before designing the game, showed that participants thought that a game should be location-based and realistic, allowing the user to do something during travel time (not only when at home). The game should also provide relevant feedback and concrete rewards (e.g. public transport discounts), educate and inform users about transport systems in the city, support users with simulations, include competitive elements and show how the user’s behavior impacts their environmental footprint. To ensure players’ engagement it should also link actions in the real world with effects in the game environment, be aligned with real-time information about traffic and transport, present specific game scenarios for tourists (e.g., treasure hunt games related to tourist guides) and be fun. Based on these users’ indications we designed a first prototype of the Eco-Dealers game that is currently under evaluation in the three trials cities of Milan, Barcelona and Helsinki. The game concept consists in a gang of traffickers that move inside a city in a sustainable way, by using public transport, with the aim of carrying out secret missions and earn *eco-money*. This purpose has to be achieved by minimizing as much as possible travel time, traffic and pollution in order to save precious *Oxygen-points* (O-points). After registration, users can join the Eco-Dealers gang and look for available missions to carry out and select one of them. Every mission, to be completed, requires travelling physically across the city, to collect virtual objects with a mobile device provided with GPS sensors (Fig.1). There are two main ways to carry out a mission: 1. By travelling by tram, bus, metro, etc. and collecting objects as required by the mission.

2. By searching (within the Eco-Dealers network) for supporters who normally or occasionally travel along the routes relevant to a certain mission or part of it. In this case the player needs to make an offer to the potential helper/supporter, who can accept, refuse or raise their offer. A user can earn eco-money by completing missions or helping other users to do so.

At the game start, players receive a bonus corresponding to 100 “eco-money”. They can earn more money by completing their own mission or part(s) of other user’s mission (Fig. 2). Eco-money is a sort of virtual reward which could be used by players to get real discounts (e.g. for public transports, eco-restaurants or stores, museums, etc.). Also, when starting the game a user is given a certain amount of

Fig.2: Getting or offering part of missions to other players in Eco-Dealers

O-points, which are vital for the player’s survival. Every time users travel and earn eco-money by completing missions as ‘owner’ or ‘helper’, they can also lose O-points if they travel in unsustainable ways (e.g. by using private car). When the O-points are finished, they can be regained in different ways, for example by spending eco-money. The game will provide a tool to help the owner of a mission to find the best journey(s) in order to save money, travel time and reduce carbon footprint. The same tool will also help to find supporters for a mission, searching through the journeys that have been offered. As can be derived from the game description, the Eco-Dealers game provides an example of design of meaningful game-experiences for sustainable mobility, where citizens can easily find realistic connections with the relevant non-game setting (in this case players can learn more about the public transport offers in a city, the impact of their travel choices in terms of carbon footprint). Players can accept or offer missions according to their needs and preferences, share a mission in order to find similar players, which can be a meaningful result of the game experience. Therefore, there is the potential for design to add further opportunities of engagement with the game and the sustainability goals (e.g., the player could become an activist and start new eco-initiatives in a certain area of one’s city).

Conclusions

This paper has presented initial thoughts from the user-centred design of game-based experiences for rehabilitation and sustainability purposes that are currently in progress. In both research projects presented results from the user requirements investigations showed that the game experiences to be designed need to be perceived as meaningful by end users, as well as easily connected with the non-game settings where desirable behaviors need to be adopted and maintained (e.g., patients compliance with home rehabilitation therapy, citizens’ eco-friendly travel choices in daily urban areas). We have also presented two examples of how these meaningful and customizable game experiences can be realized in the research fields addressed. Our future work will be focused on iteratively testing and improving the game-based solutions described to better fit their end users’ needs, as well as to inform the future design of persuasive technology for healthy living and wellbeing.

Acknowledgements

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User Experience Evaluation based on Mental Effort Measurement with PPG

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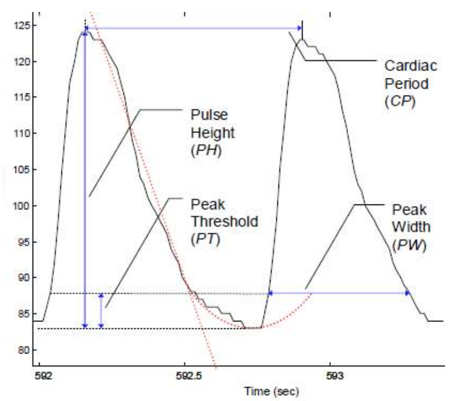
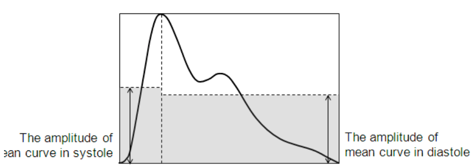
Abstract
The traditional User experience (UX) measurement models are emotional models and often not good at quantitative evaluation. It makes the evaluation results of interactive designs vulnerable to subjective variations. This study proposes a novel photoplethysmogram-based evaluation method for interactive tasks, which measures the invested mental effort through assessing the stress-induced vascular response index (sVRI). The sVRI actually reflects the physiological reaction on the peripheral vasoconstriction to the mental investment while the user is carrying out an interactive task. Experiments on the standard task difficulties and the distinguished interactions for inputting texts show the usability of the sVRI based model for evaluating the UX in a dedicated physiological dimension different from traditional emotional models.

Author Keywords
User Experience (UX) Evaluation; Mental Effort Investment; Vascular Response Index; Photoplethysmograms (PPG)

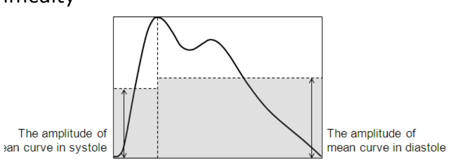
ACM Classification Keywords
H.5.2. Evaluation/methodology



igure 1. Features of the pulsatile component f the PPG used to detect standing are hown: Pulse Height (PH), Cardiac Period CP), and Peak Width (PW). A fourth feature, ıe Normalized Peak Width (NPW) is the ratio f PW to CP.



a) Pulse pattern associated with task of lower ifficulty



a) Pulse pattern associated with task of higher ifficulty

igue 2. Quantitative comparison of ormalized waveform using the mean curve ation of pulse contour in PPG measurement

Introduction

User experience (UX) is often regarded as the important criteria for evaluating the user interaction design. There are several common approaches for UX evaluation, including the nonverbal [1], verbal [2], sensual evaluation methods/tools [3] and psycho-physiological approaches [4, 5]. But some of the approaches are not verified stable and scalable enough to reflect UX in applications.

In this study, it is hypothesized that the magnitude of vascular response was positively correlated with the increase in task difficulty in association with the increase in the amount of mental effort invested in task performance. It has also been accepted that sympathetic tone is the dominant influence of systolic amplitude as well as morphology in PPG signal [8]. The waveform amplitude of PPG signals changes in association with sympathetic tone. But it is not comparable, because there is no calibration and standardization procedure for comparing waveform of one subject to another, so the uncertainty due to hardware-dependent and subject-dependent factors, or even variations in sensor placement, may influence the analysis.

Being used as a prospective discriminant quantitatively reflecting the stress induced vascular responses in photoplethysmogram appearance, it had been confirmed of significances to stressful conditions [8], and thus was used in this study in name of stress-induced vascular response index (sVRI). The sVRI can provide the quantitative recording during the interactive tasks; with user activity logging, a real-time data based analysis can be carried out to give an evaluation for the past experience.

Stress-Induced Vascular Response Index

This study proposes a quantitative vascular response index based on the PPG model of [4]. In order to quantify the vascular stress stably, the stress-induced vascular response index (sVRI) is proposed.

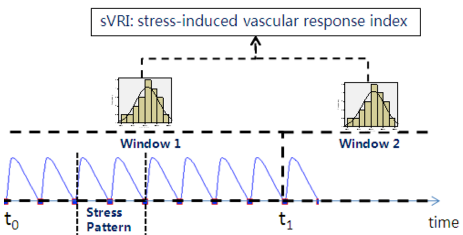
Photoplethysmograms (PPG) Measurement

Pulse oximeters measure the heart rate and blood oxygenation by illuminating the skin and measuring the intensity of the light that has propagated through it. The measured intensities, called photoplethysmograms (PPGs), are highly susceptible to motion, which can distort the PPG derived data. By illuminating the flowcell, a PPG can be measured. The motion artifacts in the PPG as a result of emitter motion are shown to correlate with the emitter’s displacement [4].

Identifying Stress

It is originally verified that mental stress results in an elevation in salivary cortisol levels as well as haemodynamic changes and peripheral vasoconstriction reflected in PPG appearance [6,7]. The easy task with less mental stress has the PPG waveform as Figure 2(a); while the hard task can have the waveform as Figure 2(b). There is an obvious amplitude elevation between the two cases。

Based on the amplitude levels, the stress-induced vascular response index can be formulated and achieved as Figure 3. The original PPG waveforms can catch the stress level of the peripheral vasoconstriction, and there are explicit patterns found to recognize it [8]. As Figure 3 shows, the sVRI model in this study realizes the window based extraction and indexing together with the statistical filtering to give the stable and good-quality sVRI outputs.



Figue 3. The original PPG waveforms are extracted as stress patterns, based on which a time window-based index evaluation algorithm is employed to give the sVRI in target window.

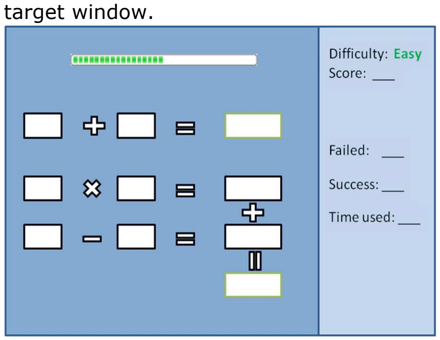


Figure 4. The arithmetic calculating software

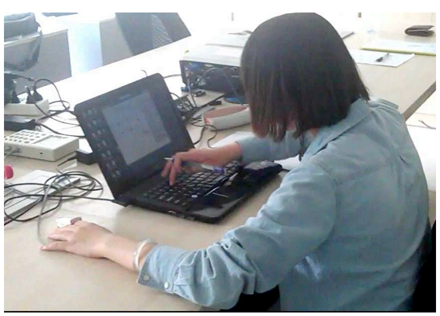


Figure 5. A participant in arithmetic calculateon.

Measuring Invested Mental Effort

Referring to the procedures and principles in paper [1-5, 6-7], a Sternberg memory task based experiment was designed to verify that the sVRI can measure the invested metal effort. This experiment also accepted the same assumption as that in [13] that the participants have the normal goal conduciveness. The main purpose of this test is to figure out whether the stress-induced vascular response index (sVRI) can distinguish the different difficulties of the tasks [13].

There were 22 participants (aged 20–27, 10 female) attending the tests, who are all the undergraduate and graduate students from universities. They were familiar with the using computers and solving arithmetic problems; they can also promise to guarantee the enough goal conduciveness. The calculating interface on the computer is shown in the following Figure 4. Results are shown in Table 1 and Table 2.

	Easy	Hard
	Mean ± SD	Mean ± SD
Pre-task	0.827 ± 0.00303	0.832 ± 0.00194
In-task	0.906 ± 0.00543	0.931 ± 0.00857
Post-task	0.825 ± 0.00305	0.844 ± 0.00256

Table 1. Mean/SD values of sVRI.

	Pre-task and in-task	In-task and post-task
Easy	6.71E-09	5.67E-09
Hard	1.96E-08	7.70E-09

Table2. High signifyiance in t-tests.

In this task, we conclude following findings:

- The sVRI measured in the easy and hard tasks designed according to standard Sternberg memory task model were of high quality.
- The sVRI reflects the different task difficulties correctly.
- The sVRI also shows clear difference between rest and slight mental effort.

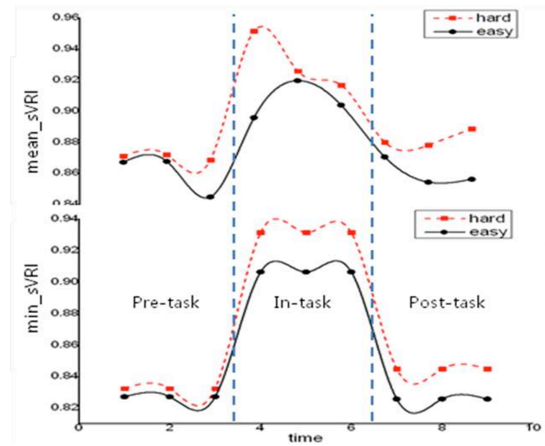


Figure 6. sVRI levels in easy and hard tasks. The easy task (solid) has less invested mental effort than the hard task (dashed), which can be reflected by sVRI efficiently and clearly.

Measuring UX in Interactive tasks

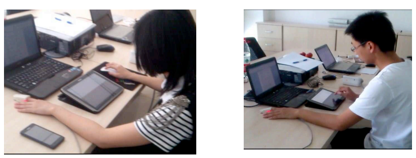
In this study, the text-inputting was selected as the testing interaction. There were two UIs selected; one is the touch-based input UI and the other is the soft keyboard-based input UI. The task is to input the words with the same difficulty. The similar sVRI measurement was done in this test like that in standard tasks. Pre-defined word lists with the same difficulty and the questionnaires were also offered. The same 22

	Touching	Clicking
	Mean ± SD	Mean ± SD
Pre-task	0.811 ± 0.00289	0.815 ± 0.00293
In-task	0.887 ± 0.00612	0.917 ± 0.00497
Post-task	0.850 ± 0.00490	0.826 ± 0.00223

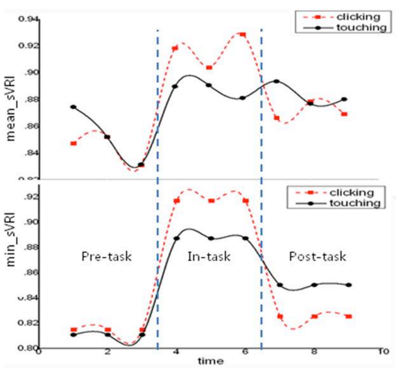
Table 3. Mean/SD values of sVRI

	Pre-task and in-task	In-task and post-task
touch	3.07E-09	5.70E-12
click	5.04E-08	4.89E-09

Table 4. High signifye in t-tests.



igure 7. mouse-clicking (left) and ouching (right) to input texts.



igure 8. sVRI levels in clicking and ouching tasks. The touching task (solid urves) has less invested mental effort (in-ask) than the clicking task (dashed urves), which can also be reflected by VRI efficiently and clearly.

participants as those in the standard tasks were invited. They were asked to finish the text-inputting procedures in inputting words via 1) the mouse-clicking and 2) the finger-touching on the touch-pad. The same graphic UI (GUI) was employed on the same pad; only the input apparatus are different.

The results are shown in Table 3 and Table 4. Figure 8 also schematically shows the difference of the sVRIs during the tests of the two inputting approaches. The upper figure shows the mean-sVRI curve of all the participants and the lower figure shows the minimal-sVRI curve of all the participants. The mean-sVRI curve was calculated through the mean values of all participants, and the minimal-sVRI curve was calculated through the mean of the minimal values in each stage among all the participants. Both curves show the same trend that the overall sVRI level of the *clicking* task was clearly higher than that of the *touching* task in the in-task stage (the participant was working). This result was in favor of the touching fashion of modern mobile interactions.

Conclusion

User experience (UX) is often regarded as the most important criteria for evaluating interaction designs. However, the traditional UX evaluation models are often not good at quantitative evaluation or do not have strong correlations with internal psycho-physiological mechanism. This study proposes a novel evaluation approach for interactive tasks based on the mental effort measurement of the user through assessing the vascular response index (sVRI), which is based on the PPG model. This model can reflect the physiological reaction to the mental effort investment while the user is carrying out an interactive task.

Experiments on the standard task difficulties and the interactive tasks for inputting texts show that the sVRI is settable and sensitive enough for the evaluation of the human-computer interactive designs. The underlying physiological behavior of the peripheral vasoconstriction may also become a novel dimension in addition to the current motional models.

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Serious Moral Games in Bioethics

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Abstract
Our contribution discusses the possibilities and limits of using video games for apprehending and reflecting on the moral actions of its players. We briefly present the results of an extended study [1] that introduces the conceptual idea of a Serious Moral Game (SMG). We outline its possible application in bioethics for training medical professionals such that they can deal better with moral problems in practice. In this way, a SMG Bioethics intends to improve psychological competences that are needed for dealing with various ethical questions within healthcare. The contribution is part of a project that aims for actually creating a SMG for training moral competences that are needed for putting bioethics in practice.

Author Keywords
Serious Moral Games; Moral Behavior; Biomedical Ethics; Training; Medicine

ACM Classification Keywords
J.3 Health

General Terms
Design; Human Factors; Measurement

Introduction

The relationship between video games and morality is widely discussed in the public realm. But instead of following the common line argument maintaining that the contents of video games rarely serve or even corrupt the understanding or promotion of moral actions, the authors consider the benefits these games might have to moral research and education. We have recently suggested that computer games may be a suitable medium for training moral competences due to their ability to allow for immersion and the creation of an intrinsic player motivation [1; see 2]. We call them "Serious Moral Games", and we propose that they may serve as an extension of current, virtual reality based training instruments in medicine. The fact that learning preferences of young adults are framed by novel media technologies [3] serves as an additional reason for advancing the use of a SMG in biomedical ethics.

We consider bioethics as a promising domain for a SMG, where medical students and professionals would be the target audience. This, because it is undisputed that training in ethics is indispensable for medical students and professionals, but it frequently has been diagnosed that the effects of courses in biomedical ethics are limited – in particular in medical students [4,5]. One reason for this may be that recognizing the relevance of ethical issues requires actual practice. But it may also be that the current training in ethics, which is usually based on deliberation of case studies, is incomplete [6]. We suspect that one shortage is the insufficient inclusion of practicing psychological competences that underlie moral behavior. This may for example explain why medical practitioners sometimes have difficulties in recognizing alternative moral standpoints or values of patients and their close relatives [7]. As a failure to include diverging moral standpoints in medical decision making can have severe effects and influences the general appreciation of medicine, training moral competences of medical professional is of general importance for improving the healthcare system.

In the following, we give a very brief overview on our study and outline the main points that have to be discussed when creating a SMG in general. This contribution is part of a larger project that aims for creating a SMG for Bioethics. We are currently defining the technical requirement specifications of such a game and we develop visualizations, e.g. for displaying the "moral profile" of a player. We hope that the workshop "Ubiquitous games and gamification for promoting behavior change and wellbeing" will provide valuable feedback for our future work.

Video Games and Morality

Up to recently, the general relationship between morality and video games was considered from a limited perspective. It was (and still is) common to debate whether certain games (such as first-person shooters) have a negative impact on the moral development of adolescents, although the findings are controversial [8].

We will not comment on this debate here, but we remark that in the last few years an increasing interest in creating "prosocial" video games shows up in several ways. Some authors strongly maintain that video games – in contrast to other instruments of moral education like stories or films – are particularly well suited for such purposes in that such games do not merely convey content; rather, the rules on which the games are based allow the player to act (within the established framework of the game) [9], and thus interact, rather than simply absorb. This "prosocial use" of video games is accompanied by a noteworthy development in the game industry. There have been for some time now games on the market in which the player has to develop explicitly moral qualities (e.g. to be cooperative) to succeed. The associated "socially conscious artificial intelligence" aspect of a game engine has become quite common in game design. Examples of such behaviors include taking responsibility or feeling empathy for other game characters, and a game flow that responds to the behavior of the players (e.g. assertive versus cautious) [10]. However, the possibility of moral decisions in such games is not usually discussed in terms of their possible realization in a video game, but in the context of cultural analysis [11].

Nevertheless, this discussion points to the possibility of creating a Serious Moral Game, i.e. a game that enables one to determine the "morality" of players, as well as that might have an effect on their behavior outside of the game world. Naturally this goal raises methodical questions, whose answers form the prerequisites for such a project:

1. What does one mean by the idea of "morality"? In a general sense, "morality" describes the social norms and values that constitute the standard for "morally correct behavior". But: What sort of norm is "moral"? To what extent are such norms bound to cultural and historical frameworks? What modes of justification do moral norms require?
2. What model of moral agency should apply? If the "morality" of a player is to be understood or changed through a SMG, then there has to be a grasp of the psychological mechanisms on which morality depends. Otherwise it would be unclear which approaches would really address the player's basic starting points.
3. Which game mechanisms are available to make determinations about the morality of the players? This relates to the possible content of the game, to the rules, and finally to the gameplay – that is, the structure that opens up the space of possibility, and therewith determines the progression of the game and, especially, the game experience.

Moral Intelligence

If a SMG is to be able to measure the morality of the players, it must be embedded in a framework that has conceptual and empirical support. This can be accomplished through a certain model informed by an account of the psychological mechanisms of moral agency, and further refined through the theory of "Moral Intelligence" [12]. Roughly put, moral intelligence refers to the set of skills the moral agent needs in order to align her behavior with the ends she has set for herself. It is thus a skill-based conception of morality or moral behavior, analogous to the concept of "emotional intelligence" that describes the ability to deal with emotions. The approach describes the sequential logic of moral behavior along with the associated underlying psychological processes, as well the way in which implicit and explicit knowledge of morality and its justifications are included. These elements underlie the five components of moral intelligence:

- *Moral compass:* This metaphor encompasses the set of moral schemata whose content is responsible for orienting the subject's behavior [13]. As such it is concerned with mental representations of both declarative and procedural knowledge, each of which is accessible to the subject in varying degrees.
- *Moral commitment:* The ability to activate or sustain a motivation for the inclusion of moral considerations in the process of perception, decision-making, and action. In contrast to the typical process logic of moral behavior (perception → decision → motivation → action, [14]) moral commitment is a capacity that influences all stages of the process, and in particular provides a motivational force to the semantic content of the moral compass.
- *Moral sensibility:* The ability to recognize morally salient aspects of a particular situation. The relevance of moral sensibility is obvious: if such moral aspects of a situation are not recognized, there is no cause to be concerned with the question of right actions.
- *Moral problem solving:* The ability to bring the morally salient features of a situation to the decision making process, and depending on the degree of conflict involved (e.g., if the problem has the structure of a dilemma) to arrive at a decision consistent with the subject's particular moral compass.
- *Moral resoluteness:* The ability to carry out the decision that is made despite, inter alia, external resistance and barriers.

Implications for a Serious Moral Game

Any attempt to measure moral behavior should reflect a central characteristic of human morality: humans are not only moral because they understand a valid moral system and act accordingly, but also because in certain situations they can put this moral system into question. It is not enough to analyze the extent to which a moral agent fulfills the demands of a moral system. One should also examine how the moral agent behaves when the applicability of specific moral norms becomes questionable in certain situations. The justified rejection of certain norms (e.g. due to changed contexts) could be a mark of moral agency, so that the way one handles these substantive commitments can be an object of empirical interest. This is of particular relevance in bioethics, as many moral problems in medicine have a dilemmatic structure where conflicting values cannot be realized in the same time. For example in psychiatry, some interventions are needed to avoid harm for the patient, but may violate the patient's autonomy. Because of that basic problem, not all components of the psychological model of a moral agent can be addressed in a similar way in a SMG:

- *Moral compass:* In order to give an account of how the behavior of the player in a game relates to her moral convictions, these convictions must be articulated in at least a rudimentary way. This may, but need not necessarily, happen through the game itself, but can happen, for example, as part of the debriefing, if game is part of a study.
- *Moral commitment:* Moral action is closely linked with the motivation to allow one's behavior to be guided by moral considerations. For a Serious Moral Game this means that the gameplay has to build in such a motivation, which is to say that moral issues must have significance to the game itself.
- *Moral sensibility:* Moral action is based on the ability to recognize that there is a moral problem presented in a given situation. Accordingly, a Serious

Moral Game has to present the moral questions in a manner that inherently allows for a corresponding moral cognition. The extent to which the individual player can effectively make use of his or her moral sensibility is one of the possible items for measurement.

- *Moral problem solving:* Although the morality of human beings is not reduced to "solving" moral issues, dealing with such difficult choices is still central. Since most games are basically structured decision spaces, this point is a 'natural' component of a Serious Moral Game. But in particular, video games could enable the implementation of very different decision making situations (e.g. those under time pressure, with limited information, etc.) within a common framework.
- *Moral resoluteness:* Moral agency is manifested in the concrete behaviors or behavior patterns of a moral agent. Since video games often utilize representations of the player, this point can be included fairly easily by including obstacles and "temptations" in the game play that must be confronted by the player.

When trying to implement such elements in a SMG one has to distinguish two evaluation levels of ethical action criteria. Games always provide opportunities for ethical behavior external to the gameplay itself, but these are not relevant when it comes to determining the components of a Serious Moral Game. Accordingly, we will hereafter focus on ethical actions within the game. Here, two evaluation levels have to be distinguished, the first of which will be illustrated using the example of the game Pong. Here, a player may, on the basis of ethical considerations, purposefully loses, or moderates his play according to the lesser abilities of his opponent. Such ethically motivated actions happen within the game, and are therefore part of the gameplay (in contrast to, say, violating the rules, which is not part of the game logic). The ethical significance of this behavior, however, lies outside of the game, in that the effects of the action obtain in the real world rather than that of the game itself. The player brings an ethical quality to his game actions by placing the game actions in a context outside of the game itself. This social context enables the player to evaluate his own actions according to ethical criteria (e.g., under the aspect of fair play).

However, the social context in which the game takes place is not the only level on which game behavior can be ethically judged, a player can invoke ethical standards for his actions, or wherein such standards can be deduced. Another is that of the game world itself, and refers to the ethical evaluation of the impact that players' actions have on the course of the game, given the way the designers have set things up.

Potential Control Parameters of a SMG

In an extensive study that is beyond this contribution, we have analyzed several paradigmatic types of current computer games with respect to their narrative setting, their game play and their ethical system [1]. In this way we identified a wide range of variables that have already been used in games and that represent potentially relevant parameters for measuring moral behavior:

- *Deliberation time:* How much time does the player have to make his decision? How does the time pressure affect the decision making process?

- *Possibilities for correction:* Does the player have the possibility to correct decisions and actions retrospectively, as in the form of rectifications, say? To what extent does this possibility effect the decision making process, especially when the player expects it?
- *Narrative variability:* Based on variations within the narration, priming effects could be examined. Variables include narrative elements such as backstory or cut scenes.
- *Different contexts of action:* The narrative setting as a whole as well as the genre of the story can be a design variable, given the appropriate effort. Different contexts can have importance for an ethical decision.
- *Different character roles:* The role of the player can be designed as a variable, as can the character's backstory, its looks, and its modes of interaction. To what extent do the features of the character determine the decision making process?
- *Interaction with NPCs:* Due to the audiovisual mode of presentation, subtle changes in the character's social environment can be built in. These variables would concern interactions with the NPCs, such as how they talk to the character.
- *Evocative level:* Based on variations in the audiovisual development of the characters, one could observe the effects of different features like age, gender, looks, etc., on the decision making process.
- *Different forms of presentation and audiovisual style:* Such elements enable the examination of framing effects. How do the form of presentation, the style, or the media processing effect the decision making process? Do realistic forms of presentation support ethical decisions more than abstract and stylized forms? How can the relationship between image and text be evaluated as a basis for ethical behavior?
- *Different perspectives:* How might the distance that the player has from events, persons, or situations, especially ones she can influence, play a role in moral agency?
- *Variable degrees of difficulty for certain tasks:* Does a player maintain her ethical values or does she abandon her conceptions of value when the actions occur under significant time pressure, or when she is faced with additional challenges?

For example, the game "Fable 2" (Microsoft, 2008) uses a moral system that is built on the dichotomies of "good and evil" and "pure and corrupt", and evaluates a large part of the game action on this basis. This system is directly tied to the character development, such that actions that are evaluated by the game from an ethical perspective as "good" or "pure" can lead to a different appearance of the character than "evil" or "corrupt" actions.

In our project, we aim for a more complex moral ontology. In the current stage, we evaluate in various paradigmatic moral dilemmas in healthcare, to what extend players will be able to discover the involved values and which of them guides their decisions. In this way, during the game, a "moral profile" of the player should emerge that informs him or her on preferences and neglects with respect to moral values inherent in medical decision making.

Conclusion

In a culture in which the digital gathering of information about social processes plays an increasingly important role, it is plausible to suppose that the interactive medium of the video game will gain general acceptance as an instrument for the acquisition of knowledge. A SMG that contains the elements articulated here and that is applied in contexts where the need for ethical training is undisputed, as in medicine, can open up opportunities for the medium beyond those of today's common design formats, thereby providing substantial support to moral research as well.

The complexity of this topic presents new kinds of challenges for the constructions of such games. The interdependence of multiple parameters, along with the difficulties of correlation and interpretation, leave designers with many hard questions. Serious Moral Games would certainly break new ground in terms of layout, structure, and interest. Nevertheless, through SMGs, awareness could develop as to how moral behavior can be better understood and applied at the level of the individual, but also concerning its significance and value within the social context.

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Automatic Recognition of Protective Behaviour in Chronic Pain Rehabilitation

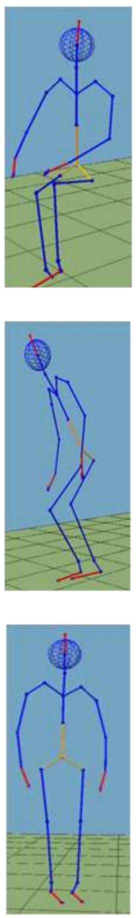

Fig.1. Example avatars generated using motion capture data of people with chronic pain: three frames from a sitting to standing exercise.

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Abstract
Exergames are increasingly being proposed for physical rehabilitation in chronic pain. They can be engaging, fun and can facilitate the setting of targets and evaluating performances through body movement tracking and multimodal feedback. While these attributes are important, it is also essential that psychological factors that lead to avoidance of physical activity are addressed in the game design. Anxiety about increased pain and/or of further damage often causes people to behave in a self-protective manner (e.g., guarding movement) and to avoid particular movements. Protective behaviour may itself cause increased pain or strain. In this paper we investigate the possibility to automatically detect such behavior. Automatic detection of protective behaviour can be used to adapt the exergame at run time to alleviate anxiety and increase treatment efficacy.

Author Keywords
Exergame; Automatic emotion recognition; Protective Behaviour; Machine Learning; Body movement.

ACM Classification Keywords
H.1.2. Human Information Processing.

PROCEDURE

Table 1. Data collection and automatic recognition procedure

Data [20]: 21 subjects with CLBP underwent 1-3 trials consisting of a range of physical exercises including sit-to-stand movements (fig. 1). Each trial lasted about 15 min. 4 experts labeled recorded videos to identify video segments with protective behaviour. Also, 105 instances of a sit-to-stand exercise were segmented from the motion capture and EMG data. A total of 47 sit-to-stand instances were labeled as *Guarding* as they had been identified by at least 3 experts as containing such behavior. The remaining 58 were labeled as *Not Guarding*.

Movement Features: Features were computed over each sit-to-stand data segment. The best recognition results were obtained by using: ranges of joint angles, means of joint energies [17] and means of rectified EMG values.

Automatic Recognition: An ensemble of 100 decision trees trained using a subset of all available features was created. Each tree was created using an in-bag sample of 2/3 of the original data.

General Terms

Algorithms; Human Factors.

Introduction

Rehabilitative therapy for chronic low back pain (CLBP) is effective so long as the subject adheres to the methods and uses them in everyday life [1]. However, adherence among people with chronic pain is often poor, partly due to the frustration and boredom of regular beneficial exercise and partly due to other psychological factors.

Exergames address some of these issues by bringing fun into exercise and to help people set targets, monitor performance and provide prompts [2, 3], but their effects tend to be weak in people with CLBP. One of most likely reasons of their limited success is that they do not take into account the psychological factors (e.g. anxiety) that lead to avoidance or caution about movements, which are wrongly believed to exacerbate pain or constitute physical risk [1, 4]. These psychological factors can undermine motivation to use exergames. If the exercises are performed despite anxiety, protective behavior can increase pain due to muscle over-contraction or failure to relax, thus wrongly confirming the fear that physical activity exacerbates pain. This problem is particularly prevalent when exercise is performed away from the guidance of a physiotherapist to provide feedback and reassurance.

Algorithms for affective state automatic detection (e.g., [5, 6, 15, 16, 21, 22]) could be used to feed back into adaptive game play to address psychological needs. In [7], for example, the shape and skills of the player’s in-game character are adapted to the player’s cognitive and physical capabilities according to the player’s stress level of the moment.

Similarly, in the context of CLBP, switching the control modality during game play from body movement to breathing patterns could, for example, prompt relaxation and increase confidence in beneficial exercises that would have otherwise been avoided. In addition, run-time encouragement, or multimedia feedback that provides a sense of control or of being monitored, could also be used for this purpose when necessary [8]. The amount of feedback during a movement and the amount of positive reinforcement on completion (e.g., [19]) can be based on the challenge of the movement and on previous avoidance patterns. However, feedback must be carefully used. Simple encouragement during an unchallenging exercise may be experienced as patronizing. Conversely, for more challenging exercises, it may bolster self-esteem [9]. Hence, switching the appropriate feedback mechanisms on and off at run-time as needed is crucial to help the person to progressively self-manage their condition [9].

To fulfill this need, the *Emo-Pain project* (www.emo-pain.ac.uk) is developing a multi-faceted virtual coaching system for CLBP rehabilitation [10, 11]. An important system requirement is the recognition of protective behaviours concomitant with fear of movement. Within the system’s framework there are two parallel recognition streams. The first is to interpret communicative levels of pain manifested as facial expressions and alterations in the voice [12, 23]. However, in this paper we focus on the second stream, the recognition of protective body movements due to anxiety or fear [13]. We acquired whole body motion data from people with CLBP (fig 1). Subjects executed

RESULTS

Table 2. Confusion matrix showing the number of out-of-bag predictions for an RF ensemble with 100 trees. G = *Guarding*, NG = *Not Guarding*. (columns: ground truth, rows: predicted outcome)

	G	**NG**
G	38 (81%)	9 (19%)
NG	12 (21%)	46 (79%)

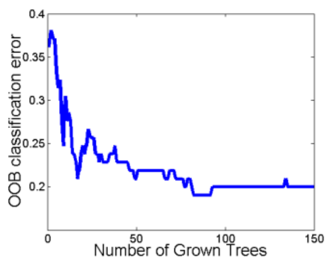

Fig 2. Out of bag classification error for an incremental number of grown trees, convergence occurs after 100 trees.

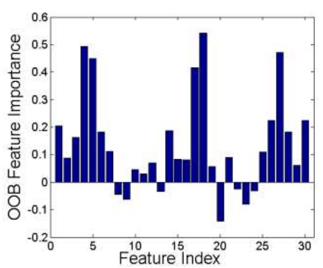

Fig. 3 Estimate of out of bag feature importance. Feature indices 1-13 for joint angle ranges, 14-26 for means of joint energy and 27-30 for the means of rectified EMG.

simple unconstrained movements while wearing a minimally invasive inertial sensor suit. We also recorded electromyography (EMG) data from the lumbar paraspinal muscles and the upper section of the trapezius muscles. Four experts (two physiotherapists and two behavioral psychologists) annotated the onset and offset timings of a set of predefined protective behaviours [20]. For data collection details see Table 1.

Recognition Method and Results

The use of machine learning methodologies for affective state recognition from body movements is a growing but underexplored area [14]. A major challenge is the high degree of complexity and variability inherent to unconstrained naturalistic whole body movements [15, 16]. The determination of features informative for learning systems is not only dependent on the affective state of interest but also on the type of action being conducted. Consequently for this study we investigate a specific sub-problem by considering one particular protective behaviour: *Guarding* [4] within motion segments of a single action type: *sit to stand* (fig. 1); thereby creating a scenario specific recognition model. In principle further models can be trained for all other behaviour/action combinations.

In this study we made no prior assumptions on which body part contributes to the expression of guarding. However, in doing this, a high dimensional input space is created. To account for this, we use the Random Forest (RF) method [18] to classify the target label *Guarding*. It is well understood that RFs are suitable for a high number of input features. Moreover, they can return estimates of the contributory importance of each feature. This is a valuable output given that feature selection for this problem is not well understood.

The results obtained using RF as a classification method for *Guarding* in *sit-to-stand* actions are showed in Table 2 (overall out of bag F1-score for *Guarding*: 0.78) and in Figure 2. Figure 3 compares the importance of the features; hip and knee angle ranges (indexed 1-6), hip and knee energies (14-19) as well as EMG (27-30) can be seen as important. Upper body angle ranges such as shoulders, elbow and neck (7-13) and their corresponding energies (20-26) return relatively low importance scores. Further analysis of the relevance of EMG vs. body form and kinematic features would be of interest to understand transferability of the approach to a simpler sensing setup (e.g., Microsoft Kinect).

Conclusions

Exergames are a new way for physical rehabilitation to introduce fun into an activity that is generally not pleasurable. However, we argue that these games should consider not only fun and performance but also target the psychological factors that constrain progress in rehabilitation by avoiding beneficial movements. By adding recognition capabilities for emotion and protective behavior into these systems, we enable game designers to adapt the game at run-time to maintain confidence and positive expectations of exercise. We present initial results in this direction.

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Design of a ubiquitous physical activity fuelled RPG

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Abstract

A regular physical activity is needed in order to maintain a correct psycho-physical balance, but being constant is one of the main obstacles, especially for people that are in the first months of activity. The project is aimed at the study and the test of an role playing game (RPG) that includes mechanics connected to the amount of physical activity tracked by each player, recorded by either self-assessment, GPS trackers or devices designed specifically (e.g. the FITBIT One).

Author Keywords

Health, Persuasive Computing, Ubiquitous Games, Game Design, RPG

ACM Classification Keywords

I.2.1 [Applications and Expert Systems]: Games.; J.3 [Life and Medical Sciences]: Health

General Terms

Health, Persuasive Computing, Ubiquitous Games

Introduction

A regular physical activity helps in making the general physical and psychological health condition of a person better[1]. The problem, however, is keeping the activity constant. This is due to a lack of motivation as the benefits from the activity need time to be evident to a person. After the initial phase the person is drawn towards physical activities thanks to various intrinsic and extrinsic motivations[3], along with the reduced anxiety generated by the release of endorphins[2].

Heart rate monitor, such as the Polar watches, have been available on the market since mid of 1980, but these devices only exposed the heart rate during physical activities to athletes. While useful to experts and people with a schedule, as it is possible for athletes to know their own heart rate at every moment, maintaining a specific effort, it is less so in giving a person motivation in starting exercising.

During the last years, however, especially after the spread of accessible smartphones on the market, various services have been created in order to keep track of one's activities. The tracking is done either via self-report, asking the user to manually input the duration of the activity and other related details (e.g. repetitions, weight lifted, distance covered), or via automatic tracking using already-available sensors (e.g. GPS, accelerometers).

Figure 1: The Fitbit One tracks physical activities using various metrics, along with sleep quality.

Some of these services (e.g. Fitocracy) use a metric which gives the users a rough idea of the effort put in a specific activity by converting standard metrics into a unified measure (e.g. by converting speed, distance, weight lifted in dimensionless "points"). The same method has been employed by devices specifically built to constantly track physical activities through the day (e.g. the NIKE Fuelband or the Fitbit One), making them more precise into tracking them. The metrics collected in such a way are then uploaded to online services to have a full range of statistics about the physical health of the user. These devices, however, have to be bought explicitly for this purpose, while smartphones are already present in the lives of people.

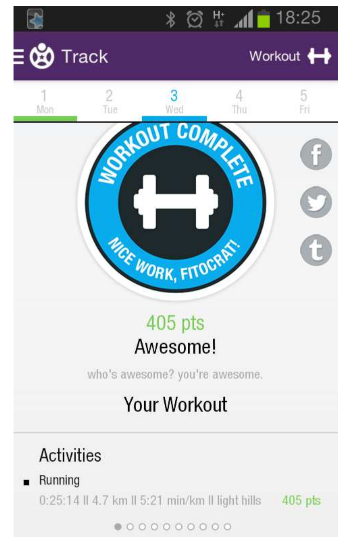

Figure 2: Fitocracy is a physical activity web service using a points system to compare the effort for each physical activity.

Most of these services provide an additional sharing feature in order to compare with others, keep connected people updated on one's achievements and, possibly, find inspiration to continue in exercising. This comparison, however, can have a detrimental effect on motivation if one confronts his or her own advancements with respect to someone that is more fit. It is also possible to join communities, integrated in physical activities tracking services, that help people into starting exercising and try to keep them constant in their activity.

Proposed idea

In order to make physical activity attractive to a broader range of people and to help maintaining it constant the idea would be to design a game that uses physical activity metrics in order to advance or gain benefits. The core metaphor is that the character controlled by the player is fuelled by his or her physical activity. The physical activity will be tracked by using specific devices, self-assessment or GPS tracking.

The game, which will be created using participatory design, will be a role playing game (RPG), in which in-game characters get better during play by gaining levels, improving their basic characteristics (e.g. strength, stamina, intelligence) and gaining new equipment. Levelling up helps the characters to survive progressively harder challenges. As physical activity metrics that can be recorded as either generic or activity specific (e.g. independent sports, aerobic or strength training) one of the decisions to take on the game design is in which form to use them. This will affect not only RPG elements such as levelling up (will the character gain levels or will it improve specific characteristics based on the activity tracked), but also affect the social part of the game.

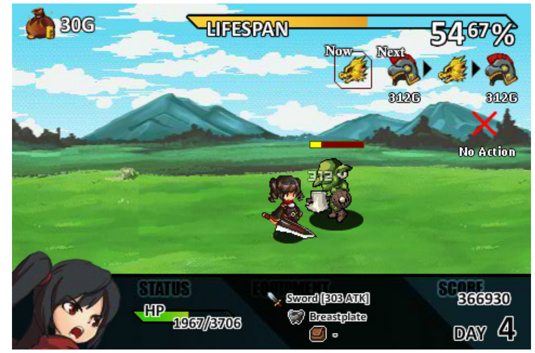

Figure 3: TriggerKnight is a simple endless running RPG

The game will integrate social interactions, allowing the player to share improvements, in-game and off-game achievements, get motivation from other gamers and so on. Differently from other physical activity social platform, however, the game will deploy co-operative interactions, hoping that this will help the players more in being consistent with their activity.

The social component, as stated before, can be both helpful and detrimental, so the balance between the co-operative and the competitive components of the game has to be tested. The choices in social relationships in the game are:

- Solo gamers
- Small, customised groups
- City wide, standardised groups

Most probably the best choice is to implement small groups, customisable by the players, as in widespread games (e.g. guilds in Final Fantasy XIV) . Another choice is how the group is represented: either as a group of different characters banding together or as a single, big entity. The target is always the same, however, which is to join forces and time spent in training together to help each other.

The way the tracked metrics are used in levelling up the characters also changes the way groups are formed. As a speculation it could be said that, on the one hand, using generic activity points as experience points (XP) used to level up, improving every characteristic at each level will generate more personal groups, as it is not important which activity every member of a group is doing. On the other hand if each activity improves a specific characteristic building an heterogeneous group will help everyone in the team in overcoming different obstacles.

Other features that will be implemented are off-game quests (e.g. lifetime cumulative distance ran, speed reached), skill level milestones, community voted challenges and time related quests (e.g. end-of-summer running, beach volley tournaments). It is hoped that these additional features will help maintaining a long term involvement in the players, along with creating various players communities.

The game effectiveness will be tested using groups of people of different athletic skill levels, employing control groups using different tracking systems. To assess the effectiveness the dropout rate will be recorded during longer time spans, along with gains in each relevant activity and perceived fun.

It is not impossible that the project results will show that this kind of approach is not useful for helping people being constant in physical activities, as there is a non-zero probability that using too many extrinsic rewards will mean that the players, once they get bored with the game, will stop completely their connected activities. Would this be the outcome of the study it would mean that using gaming mechanics for health-related persuasive technologies is not a good idea and other kinds of approaches (or other kind of game metaphors) should be explored.

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DRAMATRIC: Inducing Museum Conversation in Groups via Coordinated Narrative Variations

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Abstract
Small groups can have a better museum visit when that visit is social and educational, leading to spontaneous conversation. We created DRAMATRIC, a mobile drama presentation system for small groups of museum visitors, that receives sensor data from the museum environment about the group during their visit. Observing their activity, DRAMATRIC adaptively delivers a series of dramatic scenes about nearby exhibits. Each drama presentation contains small, complementary differences in the narrative heard by different group members, causing them to fill in missing pieces in the drama by discussing them with their fellows. We tested whether switching from a drama using one type of narrative difference to another in the subsequent drama results in increased conversation. A refined prototype will be tested at the MUSE science museum in Trento, Italy.

Group-Based Museum Audio Dramas
Visitors mostly come to museums in social groups: 45% in organized groups, 20% with friends and 30% with children, while only 5% come to the museum alone [5]. Improving the experience for group members is connected to increasing how much they interact and talk to each other, as ethnographic studies clearly show [4]. The length and quality of conversation within these small groups of visitors in a museum can be seen as a fundamental indicator of successful engagement for a small group.

Recent years have seen the use of adaptive mobile guides [2, 6] for individual visitors in instrumented museums, perhaps with social features to increase interaction [1, 3]. But these presentation systems remain fact-based. A much different approach is to use presentations that evoke emotion, such as performed narrative like drama or film.

Mobile intelligent systems allow us to increase interaction in new ways. We decided to show slightly varied dramatic narratives to different individuals or subgroups of a small group while they are listening to the same dramatic scene. The combination of emotional reactions to the drama, the engagement of participants standing in front of museum exhibits, and the internal desire to discover the missing narrative elements, we hope is manifested as ensuing conversation and thus an improved museum experience.

Figure 1: Insert a caption below each figure.

Narrative Variations and DRAMATRIC

We created the DRAMATRIC system (Drama Tension Release by Inducing Conversation) that uses a novel group-oriented approach integrating sensors and analysis of the resulting sensor data into a coordinated narrative system for mobile devices (specifically, Android phones) in an instrumented museum. DRAMATRIC is based on adaptive narration, where by adaptivity we mean using observed and inferred characteristics of group behavior to choose when and which drama-based presentation to show, as well as how to link successive dramatic scenes together. DRAMATRIC allows a group of visitors to move freely around a museum along any path they choose, and produces a larger drama by stitching together smaller drama segments and ensuring a coherent narrative regardless of that path. Sensors both in the museum and worn by the visitors allow DRAMATRIC to determine (a) where group members are, (b) objective characteristics such as proximity between members, who is speaking, and the length of conversational turns, and (c) inferable characteristics, such as who is the leader, or how much time they stay near each other throughout their visit.

To increase the amount of interaction, we present slightly different audio dramas to different group members by selectively withholding information from some members of a group but not others. We connect narrative variations to increased conversation by purposefully writing the dramas and manipulating the audio in such a way that each scene is missing one of the key points that narratively completes that scene. By carefully structuring these“gaps”, each person can be given content that their fellow group members require in order to completely understand the events in the scene. We have developed three specific techniques to provide for this narrative content variation:

- Mr. Mani: A one-sided conversation style where the audio of only one character can be heard as if via telephone so we can’t hear the other party. Pauses, music or sound effects are inserted to indicate the other character whom we cant hear is speaking.
- Audio blurring: This technique overlays the dialogue at selected points with some source of ambient noise (*e.g.*, seagulls screaming, children yelling, the sound of waves or wind, etc.). The dialogue at these key points is thus rendered unintelligible. However, the group members can still tell that the characters are conversing, as the volume of the interference is just below the volume of the dialogue.
- Point of View Change: When there is a social conflict between two or more characters, we can allow each character to present their own viewpoint without interference. We thus have a monologue instead of a dialogue that reflects the point of view

of only one characters, while other group members hear the point of view of a different character.

DRAMATRIC presents audio dramas to small groups of museum visitors using smartphones or tablets as the presentation device (they have a color screen, earphones, WiFi, and various internal sensors such as a compass). Each device communicates with the other devices in the group and with a coordinating server [3], and has access to position, proximity and voice information coming from all the sensor devices belonging to the group.

When visitors are walking around the museum and not hearing a presentation, a map of the museum is displayed along with a picture of what they should be seeing around them. The visitor's current location on the map is updated whenever the underlying positioning system locks on to them. Once the group arrives at the location of a playable presentation, the map disappears and a static drama scene is shown while the audio drama begins.

Ambient sensors report three items of information in the museum environment each second: visitor position, proximity of one person relative to another, and the vocal intensity level of their conversation. A wireless sensor network receives updates from *mobile nodes*, small neck-worn devices that detect when they are in range of fixed radio beacons or other mobile devices, and *beacons*, stationary battery-powered WiFi boxes placed above a museum exhibit that emit a code allowing the positioning server to determine which exhibit they are near.

Knowing visitor position is necessary to initiate the proper drama at the right time, while visitor proximity enables the system to determine the degree of group cohesion. Individual voice activity detection is also important for inferring group conversation, and since the mobile nodes' microphones are pointed upwards towards the wearers mouth, the difference in intensity of the audio signal between two mobile nodes in close proximity can help determine that conversation is occurring, and its characteristics: who is talking to whom, the length of conversational turns, and who talks most or least. Further inference allows us to assess the effectiveness of the any given narrative variation techniques by looking at how much conversation occurred immediately afterwards.

Visitors hear self-contained drama segments that are combined adaptively and dynamically, and the next variation technique can be algorithmically determined based on sensor data. We currently sum the voice level readings during a 1-minute “observation period” after drama presentations. If this average is above a threshold we assume that the current technique is working and retain it for the next drama; otherwise we switch techniques to see if a new one will increase conversation.

During each presentation visitors listen to their audio channel, while on their own phones screen they see a set of images representing the main and supporting characters speaking in that drama, along with information about who or what they and the other group members are hearing. For instance, if visitors Antonio and Emily are listening to a scene on a ship, Emily might be listening to the ships carpenter while seeing a large picture of the carpenter with a message saying You are hearing the Carpenter, next to a small picture of the captain with a message under it saying Antonio is hearing the Captain, while Antonio sees the version appropriate for him. The screens graphics are kept deliberately simple to enable visitors to quickly understand who is hearing which characters, and to allow visitors to spend more time looking at the artifacts themselves or interact with each other rather than staring at their smartphone screens.

Technique Switch Museum Experiment

We wanted to explore the space of potential adaptivity functions by looking at a Technique Switch hypothesis: that changing from one variation technique to another in successive audio drama scenes will have an impact on the amount and/or quality of conversation. Specifically, we chose to test two dramas using the Mr. Mani technique, then either continuing with the same technique (Condition 1) or changing to the Blurring technique in the third drama (Condition 2). This allowed us to test the consequences of technique change with an eye toward exploring what types of adaptivity might be successful.

The evaluation of DRAMATRIC consisted of 20 pairs of subjects walking through the museum listening to the dramas at each beacon with a smartphone equipped with earphones. Subjects were recruited from responses to advertisements near the museum. They were given brief training, showing them how to use the device, and how to find their way to the beacon positions using the map on the device. To determine how much each pair talked, as well as the content of their conversations after the experimental manipulation, we attached a small digital voice recorder to the mobile node worn around their necks.

To confirm the Technique Switch hypothesis, we needed to look at how much subject pairs talked to each other immediately after hearing the audio drama. We thus measured the amount of talking in 1- and 5-second intervals over the 1-minute period in terms of total elapsed time, conversational turns and semantic annotations. The results show that pairs in Condition 2 talk slightly more in the first two dramas, but immediately after in drama 3 there is a striking change: pairs in Condition 1 talk significantly more $\chi^2(1, 1476) = 11.8, p < 0.001$. Thus the general hypothesis was confirmed: switching techniques had a significant impact on the amount of conversation. More specifically, switching from the Mr. Mani technique to the Blurring technique did not result in more conversation than remaining with the previous technique (Mr. Mani): the amount of talking was significantly lower after switching technique in the third primary drama segment (32.1 seconds for Condition 2 compared to 42.56 seconds for Condition 1, or a 24.6% decrease, $\chi^2(1, 1476) = 21.2, p < 0.001$).

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Developing Serious Games With The APEX Framework

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Abstract
APEX was developed as a framework for the prototyping of ubiquitous computing (ubicomp) environments. In this paper we explore its role as a platform for developing serious games. In particular we describe the Asthma game which is aimed at raising awareness of Asthma triggers among children. The game is designed to stimulate a healthier life-style for children with ashma.

Author Keywords
Serious games, Ashma, virtual worlds

ACM Classification Keywords
I.3.7 [Three-Dimensional Graphics and Realism]: Virtual reality.; K.8.0 [Personal Computing]: Games.

General Terms
Human Factors, Design

Introduction
Serious games encourage playing in order to learn rather than merely to entertain. Games can be used to instruct and to inform as well as to provide pleasure. This paper explores the use of a framework for the prototyping of ubicomp environments as a means of the rapid development of serious games. In particular the game that addresses the problems that children with asthma face is

used as an example. The status of the project and lessons learnt are presented.

The APEX platform

APEX (rApid Prototyping for user EXperience) [4] was originally developed for the rapid prototyping of ubiquitous computing environments. The tool enables simulation and analysis of an environment in the early phases of its development. The APEX platform consists of several components that support multiple layers of development using different levels of abstraction. The four main components are: 1) a behavioural component, responsible for managing the behaviour of the prototype, which is based on CPN Tools that use Coloured Petri Nets (CPN) [3] models to describe the virtual environment's behaviour in response to user action and context change; 2) a virtual environment component, responsible for managing the physical appearance and layout of the prototype, that is based on a virtual environment simulator (OpenSimulator[1]); 3) a physical component, responsible for supporting connections to external physical devices, such as smart phones and sensors; 4) a communication/execution component, responsible for the data exchange among all components and for the execution of the simulation.

Each layer supports a specific type of evaluation: analysis of the behavioural model (in the modelling layer); observation of environment and users' behaviour within the virtual world (in the simulation layer); observation of real objects connected to the virtual world, and user reaction to them (in the physical layer).

The paper proposes the use of APEX for the rapid development of serious games inside virtual environments' simulations (cf. [2]). The aim of the proposed game is to improve health education of child asthma sufferers thereby improving quality of life.

Asthma

Asthma [1] is a chronic inflammatory disease of the respiratory tract characterized by variable and recurring symptoms, reversible airflow obstruction, and bronchospasm.

Asthma attacks have numerous causes, among which the most common are allergen intake during feeding or medication and inhalation of certain substances when breathing, such as pollen, smoke, animal dander, or dust. Many of the substances that cause asthma attacks are directly related to the existence of abundant mites. These substances are very often in our homes. There are several procedures that prevent the domestic causes of asthma attacks, but these procedures are not always carried out in practice because because of a lack of awareness of causes. Parents and mainly children need support to identify what triggers asthma, and to take appropriate action. Government and non-government organizations have developed home environment checklists (cf. [5]) but these lists are not the most appropriate way of encouraging children to learn them.

The Game

The game described in this paper aims to present players with the basic procedures that are required to avoid asthma attacks at home. Playing the game entails connecting, using an appropriate viewer, to the server hosting the virtual environment. By using an immersive environment, players are better able to relate situations in the game to their daily life.

[1] Opensimulator: http://opensimulator.org/

Figure 1: Pets in a bedroom

The model of a house was developed and enriched with objects from online libraries (using Google 3D Warehouse[2]). Locations in the house were related to some of the main causes of asthma attacks (see Figure 1). Next to each one of the triggers a character is placed that functions as a facilitator of learning. These characters take care of questions associated with the asthma triggers next to them. Each question has four statements associated with the asthma trigger. Of these statements, only one or two can be correct and the player must identify them. The statements in each question explain how to proceed when faced with the relevant trigger to avoid ashma attacks. For each correct answer the player gets a word. At the end of the game the words will complete a sentence about asthma. In this way the player is encouraged to correctly answer all questions. After answering all questions, the player is notified that the game has ended and how many of the answers given were wrong.

The specification of the game's logic is achieved by a combination of LSL (Linden Scripting Language) scripts directly in the environment, and CPN models in the behavioural component. We have experimented with different approaches to describing the behaviour, placing more or less control logic in the CPN models. The game is easily configurable, so new asthma triggers and corresponding questions can be inserted into the environment using the viewer.

User Study

To assess the ability of the virtual environment as an aid to learning, as well as the acceptability of the game, a usability study was carried out. The target audience in this experiment were young people aged between 9 and 10 years, attending the fourth year of primary school. Since all the children were in possession of a personal computer with enough features and capabilities to run the game, their machines were used.

The procedure began with the preparation of all the machines to play the game. *Cool viewer* was installed and configured. The instructions were then given so that all users could use the platform without problems. Then, all users had at least 30 minutes to try to complete the asthma game. After this period, each of the players completed a 3-point Likert scale questionnaire describing their experience of using the game. The data collected helped to better understand the shortcomings of this first version of the game, and to determine what possible improvements could be implemented to increase educational value as well as to improve gameplay.

While the reaction to the game was positive (e.g. 12 out of 18 players found the game easy to play, and none difficult), it was found that some of the props used in the virtual environment, as well as the public availability of configuration options in the virtual server environment

[2]http://sketchup.google.com/3dwarehouse/

used, contributed to some confusion in terms of the purpose of the game: 1) It was found that one of the main factors of distraction was that the water surrounding the game environment could be entered and the bottom of the sea explored for some distance. 2) The fact the players could fly was also a major distracting factor. 3) Another aspect which decreased the focus of the game was the ability to create new objects in the virtual world, as well as changing or removing existing ones. 4) The chat feature was another OpenSimulator feature which contributed to the lack of focus during the experiment.

A reason that may explain the confusion is that while some users stated that they had experience with computer games none of them had previously experimented with Opensimulator. Several Opensimulator features where new to them and their novelty would explain why these features distracted them.

Game redesign

In order to better focus users on the goals of the game, thereby improving learning about prevention of asthma, a second version of the game was developed. To avoid the first problem identified above, a barrier was placed between land and water, to restrict the area of the game. However users still had the possibility of entering the water area by activating the flight mode to overcome obstacles. Hence, the flight mode was disabled. A significant number of players lost time changing the environment. To avoid these distractions, the functionalities of editing the environment were blocked. Despite chat being found a distracting factor, this feature could not be disabled as it is used during the game to count the correctness of the responses for each player.

Players from the first user study continued to use the game of their own volition after the first use. This provided an opportunity to record all accesses made subsequently by the users. This type of information may prove useful for future analyses of platform use.

Conclusions and future work

At this stage we are preparing a second study with the new version of the game. So far we have learnt that while virtual environments proved engaging, there is a need to restrict what avatars can do to promote a focus on the objectives of the game. We also believe that the novelty of certain features had impact in distracting the players from the goals of the game. A new study with users with Opensimulator experience will hopefully validate this assumption. In addition, due to desire by users to return to the game outside the experiment, positive results and facility for creating new games, the APEX platform seems a promising approach for the rapid development of serious games and to support behaviour change and wellbeing.

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